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[Intervention Review]

Initial arch wires for alignment of crooked teeth with fixed orthodontic braces

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ABSTRACT

Background

The initial arch wire is the first arch wire to be inserted into the fixed appliance at the beginning of orthodontic treatment and is used mainly for correcting crowding and rotations of teeth. With a number of orthodontic arch wires available for initial tooth alignment, it is important to understand which wire is most efficient, as well as which wires cause the least amount of root resorption and pain during the initial aligning stage of treatment.

Objectives

To identify and assess the evidence for the effects of initial arch wires for alignment of teeth with fixed orthodontic braces in relation to alignment speed, root resorption and pain intensity.

Search methods

We searched the following electronic databases: the Cochrane Oral Health Group's Trials Register (30th November 2009), CENTRAL (*The Cochrane Library* 2009, Issue 4), MEDLINE (1950 to 30th November 2009) and EMBASE (1980 to 30th November 2009). Reference lists of articles were also searched. There was no restriction with regard to publication status or language of publication. We contacted all authors of included studies to identify additional studies.

Selection criteria

Randomised controlled trials (RCTs) of initial arch wires to align crooked teeth with fixed orthodontic braces were selected. Only studies involving patients with upper and/or lower full arch fixed orthodontic appliances were included.

Data collection and analysis

Two review authors were responsible for study selection, validity assessment and data extraction. All disagreements were resolved by discussion amongst the review team. Corresponding authors of included studies were contacted to obtain missing information.

Main results

Seven RCTs, with 517 participants, provided data for this review. Among them, five trials investigated the speed of initial tooth alignment comparing: 0.016 inch ion-implanted A-NiTi wire versus 0.016 inch A-NiTi versus 0.0175 multistrand stainless steel wire; 0.016x0.022 inch medium force active M-NiTi wire versus 0.016x0.022 inch graded force active M-NiTi wire versus 0.0155 inch multistrand stainless steel wire; 0.016 inch superelastic NiTi wire versus 0.016 inch NiTi wire; 0.014 inch superelastic NiTi wire versus 0.0155 inch multistrand stainless steel wire; 0.016 inch CuNiTi wire versus 0.016 inch NiTi wire. The other two studies investigated pain intensity experienced by patients during the initial stage of treatment comparing: 0.014 inch superelastic NiTi wire versus 0.014 inch NiTi wire; 0.014 inch superelastic NiTi wire versus 0.015 inch multistrand stainless steel wire. Data analyses were often inappropriate within the included studies.

Authors' conclusions

There is some evidence to suggest that there is no difference between the speed of tooth alignment or pain experienced by patients when using one initial aligning arch wire over another. However, in view of the general poor quality of the including trials, these results should be viewed with caution. Further RCTs are required.

PLAIN LANGUAGE SUMMARY

Initial arch wires for alignment of crooked teeth with fixed orthodontic braces

Fixed orthodontic appliance treatment may use arch wires to exert force upon teeth. The success of a 'fixed appliance' orthodontic treatment may depend on the selection of arch wires. The initial arch wire is the first arch wire to be inserted into the fixed appliance at the beginning of the orthodontic treatment and is used mainly for correcting crowding and rotations of teeth i.e. 'crooked teeth'. There is some evidence to suggest there is no difference between the speed of tooth alignment or pain experienced by patients when using one initial aligning arch wire over another. However, in view of the general poor quality of the including trials, these results should be viewed with caution. Further research to study initial arch wires is required.

SUMMARY OF FINDINGS FOR THE MAIN COMPARISON *[Explanation]*

0.016 inch superelastic NiTi wire compared with 0.016 inch NiTi wire for initial alignment of crooked teeth

Patient or population: Patients with full arch fixed orthodontic appliances
Settings: UK
Intervention: 0.016 inch superelastic NiTi wire
Comparison: 0.016 inch NiTi wire

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No of Participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	0.016 NiTi wire	0.016 superelastic NiTi wire				
Alignment rate (contact point movement) 35 days	The mean contact point movement in 0.016 NiTi group was on average 1. 42 mm	The mean contact point movement in 0.016 superelastic NiTi group was on average 1.7 mm	0.28 [-0.33, 0.89]	40 (1 study)	+++O moderate	Too small sample size

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: Confidence interval; RR: Risk Ratio.

GRADE Working Group grades of evidence
High quality: Further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: We are very uncertain about the estimate.

BACKGROUND

Description of the condition

Contemporary orthodontic treatment involves the use of both fixed and removable appliances. In recent years, it has been shown that the quality of the result obtained with fixed orthodontic appliances is superior to that obtained with removable orthodontic appliances (O'Brien 1993; Richmond 1993). Treatment with fixed orthodontic appliances has therefore become dominant in orthodontic practice worldwide.

Orthodontic treatment is mainly carried out for adolescents who are 10 to 15 years old and is concerned primarily with correcting crowded, rotated, buried and/or prominent front teeth. Epidemiological investigation reveals that 77% in northeast Brazil (Marques 2007) and 29% in Nairobi (Ng'ang'a 1997) of 13- to 15-year-old adolescents have either a moderate or great need for orthodontic treatment. It is also reported that over 52.3% of 12-year old children in South Africa have an identifiable malocclusion (Van Wyk 2005) and 23.5% of the 12-year olds and 18.5% of 15- to 16-year-olds in Spain have a definite treatment need (Manzanera 2009). However, adults also demand and/or need orthodontic treatment and now comprise up to almost 25% of cases in US orthodontic practices (Keim 2002).

Description of the intervention

Fixed orthodontic appliance treatment uses arch wires to exert a force upon teeth. The success of 'fixed appliance' orthodontic treatment may depend on the selection of arch wires. The initial arch wire is the first arch wire to be inserted into the fixed appliance at the beginning of the treatment and is used mainly for correcting crowding and rotations of teeth. Light and continuous forces are desirable to achieve physiologic (normal) forces and controlled tooth movement with minimum pathologic (detrimental) repercussions to the teeth and their surrounding structures (Burstone 1981; Linge 1991). Clinically, this means that optimal forces result in the maximum speed of tooth movement with the minimum of root resorption and/or pain for the patient.

The forces delivered by the arch wires depend largely on the physical properties and dimension of the wire material. The initial arch wires should ideally have:

(1) Good spring-back, light and continuous force delivery;

(2) Formability, low friction, the ability to be welded, biocompatibility; and

(3) Low cost (Kapila 1989; Proffit 2000).

Precious metal alloys were used for initial arch wires for many years but high cost has limited their use and they are now virtually obsolete in orthodontics. Stainless steel has comparatively good strength and springiness, corrosion resistance and low cost. Stainless steel arch wires can be bent to almost any desired shape without breaking. Among stainless steel wires, multistrand wires offer an impressive combination of strength and spring qualities. Multistrand wires are generated by twisting two or more strands of a small diameter wire ($\leq$ 0.01 inch), therefore turning a springy wire into a cable. The properties of multistrand wires depend both on the characteristics of the individual wire strands and on how tightly they have been woven together (Proffit 2000).

Stainless steel wires have reduced in popularity for initial alignment with the developments in nickel-titanium (NiTi) wire technology but are still used by a small proportion of orthodontists. NiTi alloys can exist in more than one form or crystal structure: the martensitic (M) form and the austenitic (A) form. According to the crystal structure within NiTi alloys, NiTi wires can be classified as follows.

(1) M-NiTi which are in a stabilized martensitic form, with no application of phase transition effects.

(2) A-NiTi which have an active austenitic grain structure and are subject to phase transformation under comparatively low temperature and stress.

M-NiTi wires are commercially available and have several names, for example Nitinol, Titanal and Orthonol. All the M-NiTi wires have good spring-back and enough strength but poor formability whereas A-NiTi wires exhibit a superelastic property. Superelasticity means that wires exert about the same force irrespective of whether they are deflected either a relatively small or large distance, which is a unique and extremely desirable characteristic in relation to minimising root resorption. A-NiTi wires are very soft at room temperature and become elastic at mouth temperature. These properties make them easier to place into fixed appliances initially but difficult to bend or permanently distort (Burstone 1985; Miura 1986). A-NiTi wires are marketed under several trade names, for example Sentinol, Ni-Ti, Cu-NiTi and NiTi-SE.

Beta-titanium (Beta-Ti) is another titanium alloy used in orthodontics. Beta-Ti theoretically offers a highly desirable combination of strength and springiness, as well as reasonably good formability. The properties of Beta-Ti wires are, in many ways, intermediate between stainless steel and M-NiTi but are not used routinely by most orthodontists due to inferior tooth control and relatively high cost.

The performance of arch wires is determined not only by the material properties but also by geometric factors, such as the cross-sectional shape (whether the arch wire is circular, rectangular, or square), length (i.e. inter-bracket span) and diameter. It is a general rule that for a certain material, as the diameter of a wire decreases, its strength decreases while conversely as diameter increases, its stiffness increases.

How the intervention might work

Excluding cost, NiTi arch wires have many theoretical advantages over others in the initial alignment of the teeth. However, the conclusions of some published clinical trials have not agreed with those of laboratory tests and have found no significant differences

in alignment efficiency between NiTi wires and multistrand wires (Cobb 1998; Evans 1998; West 1995). However, another trial has proved that a greater amount of tooth movement occurs with superelastic NiTi wires, although the accompanying root resorption was greater (Weiland 2003). Bearing these studies in mind, there are no definite conclusions as to which arch wire is best for moving teeth whilst causing the least root resorption or pain during the initial alignment of the teeth (Erdinc 2004; Fernandes 1998).

Why it is important to do this review

With a number of orthodontic arch wires available for initial tooth alignment, it is important to understand which wire is most efficient, as well as which wire causes the least amount of root resorption and pain during the initial aligning stage of treatment.

OBJECTIVES

To assess the effects of initial arch wires for the alignment of teeth with fixed orthodontic braces, in terms of:

(1) The speed of initial tooth alignment;

(2) The amount of root resorption accompanying tooth movement; and

(3) The intensity of pain experienced by patients during the initial alignment stage of treatment.

Null hypothesis:

There are no differences in the effects of initial arch wires in terms of the speed of initial tooth alignment, the amount of root resorption accompanying tooth movement and the intensity of pain experienced by patients during the initial alignment stage of treatment.

METHODS

Criteria for considering studies for this review

Types of studies

Randomised controlled clinical trials were included in this review.

Types of participants

Patients with upper and/or lower full arch fixed orthodontic appliances were included. Patients with palatal expansion devices or extraoral appliances, which were being used concurrently, were excluded. Patients who had previous active orthodontic treatment or relevant medical history were also excluded.

Types of interventions

Initial arch wires are the first arch wires inserted into fixed orthodontic appliances at the beginning of treatment. This excludes arch wires used at subsequent orthodontic appointments. The comparisons between arch wires of different materials and sizes were undertaken in terms of:
(1) The material of the arch wires;
(2) The cross-sectional shape of the arch wires; and
(3) The cross-sectional size of the arch wires.

Types of outcome measures

- The amount of tooth movement per month, measured in mm or by any index of malocclusion, was recorded.
- Dichotomous data, on the presence or absence of root resorption, were recorded. If there was any root resorption present, size and/or area of resorption were also included.
- Pain intensity, measured on a visual analogue scale (VAS), and/or categorical scale and duration of pain, were also recorded. Pain scores were assessed at specific time points i.e. after the initial arch wires were inserted.

Primary outcomes

(1) The alignment rate per month.
(2) The incidence/prevalence and amount of root resorption.

Secondary outcomes

(1) Time to next/working arch wire.
(2) Time to alignment.
(3) The intensity of pain experienced by patients.

Search methods for identification of studies

Electronic searches

Search strategies were developed for each database to identify studies in conjunction with the Cochrane Oral Health Group Trials Search Co-ordinator. These were based on the search strategy developed for MEDLINE (OVID) but revised for individual databases. A comprehensive search was carried out irrespective of the publication language. Papers not in English were included if they could be translated. The MEDLINE search strategy

used a combination of controlled vocabulary and free text terms and was run with the Cochrane Highly Sensitive Search Strategy (CHSSS) for identifying randomised trials as published in the *Cochrane Handbook of Systematic Reviews of Interventions* 5.0.2 (Higgins 2009). Details are provided in Appendix 1; Appendix 2; Appendix 3; Appendix 4; Appendix 5 and Appendix 6.

The following electronic databases were searched:

- Cochrane Oral Health Group's Trials Register (to 30th November 2009)
- Cochrane Central Register of Controlled Trials (CENTRAL) (*The Cochrane Library* 2009, Issue 4)
- MEDLINE via OVID (1950 to 30th November 2009)
- EMBASE via OVID (1980 to 30th November 2009).

Searching other resources

Grey literature

Conference proceedings and abstracts from the British Orthodontic Conference, European Orthodontic Conference and the International Association for Dental Research were searched.

Handsearching

Handsearching of the following journals that was carried out as part of the Cochrane Oral Health Group's handsearching programme, and was updated to the following issues:

- *American Journal of Orthodontics and Dentofacial Orthopedics* (to 2009;136(6))
- *Angle Orthodontist* (to 2010;80(2))
- *European Journal of Orthodontics* (to 2009;31(6))
- *Journal of Orthodontics* (and the predecessor, the *British Journal of Orthodontics*) (to 2009;36(4)).

In addition, the following journals were handsearched from their inception to the following issues:

- *Seminars in Orthodontics* (from 1995 to 2009;15(4))
- *Clinical Orthodontics and Research* (from 1998 to 2009;12(4))
- *Australian Orthodontic Journal* (from 1956 to 2009;25(1)).

Reference lists

The reference lists of potential clinical trials were checked to identify any additional studies.

Correspondence

The corresponding authors of all included trials were contacted in an attempt to identify unpublished or ongoing studies and to clarify trial details, if required. Manufacturers were contacted to confirm the type of arch wires and were also asked about their knowledge of any unpublished and/or ongoing clinical trials.

Data collection and analysis

Selection of studies

Two review authors (Fan Jian (FJ) and Grant T McIntyre (GTM)) independently assessed the titles and abstracts (when available) of all reports identified by the search strategies as being potentially relevant to the review. The full reports were then obtained for all studies which appeared to meet the inclusion criteria or if there was insufficient information to make a clear decision or where there was disagreement between the review authors about eligibility. The full reports were assessed to verify whether the studies met the inclusion criteria. Any disagreements between the two review authors were resolved by discussion or the involvement of another review author as an arbiter. A record of all decisions made about the identified studies was kept. The review authors were not blinded to author(s), institution or site of publication of all studies. Agreement between and within the review authors about the eligibility of these reports was assessed using the Kappa statistic.

The following screening exclusion criteria were used:

(1) Studies other than randomised controlled clinical trials.

(2) Studies not investigating fixed appliance orthodontic treatment.

(3) Studies not investigating initial arch wire interventions, including those with multiple wires as part of a sequence.

Data extraction and management

Two review authors (Yan Wang (YW) and GTM) carried out data extraction independently and in duplicate. All disagreements were resolved by discussion with one of the other review authors in the team.

The following data were collected on a customized data collection form.

- Date that the study was conducted.
- Year of publication.
- Treatments including details of material, size and brand of arch wire and type of fixed orthodontic appliances that were used.
- Duration of follow-up.
- Sample size and the number of male subjects and female subjects per study group.
- Age of subjects.
- Outcome measures.

Data on cost of arch wire and amount of time for arch wire placement were recorded.

Assessment of risk of bias in included studies

The assessment of the risk of bias in each of the included studies was undertaken independently by two review authors (Taixiang Wu (TW) and Declan T Millett (DTM)). Disagreements were resolved by discussion or the involvement of another review author.

This was carried out using The Cochrane Collaboration's tool for assessing risk of bias and a 'Risk of bias' table was completed for each study as outlined in the *Cochrane Handbook for Systematic Reviews of Interventions* 5.0.2 (Higgins 2009). Six domains, namely sequence generation, allocation concealment, blinding, incomplete outcome data, selective outcome reporting and other sources of bias were assessed according to the tool. Each domain included one or more specific entries in a 'Risk of bias' table. Within each entry, what was reported in the study was described and a judgement relating to the risk of bias for that entry was assigned. This was achieved by answering a pre-specified question about the adequacy of the study in relation to the entry. A judgement of:

- 'Yes' indicated low risk of bias;
- 'No' indicated high risk of bias; and
- 'Unclear' indicated unclear or unknown risk of bias.

After taking into account the additional information provided by the authors of the trials, the overall risk of bias in included studies was assessed using four key domains: sequence generation, allocation concealment, blinding of outcome assessment and completeness of follow-up. Studies were graded into the following categories.

- Low risk of bias (plausible bias unlikely to seriously alter the results) if sequence generation, outcome assessment blinding and completeness of follow-up were considered adequate.
- Moderate risk of bias (plausible bias that raises some doubt about the results) if two out of the four categories did not record a 'Yes'.
- High risk of bias (plausible bias that seriously weakens confidence in the results) if study did not record a 'Yes' in three or more of the four main categories.

Measures of treatment effect

The statistical procedures outlined in the *Cochrane Handbook for Systematic Reviews of Interventions* 5.0.2 (Higgins 2009) were followed and the data were analysed using Review Manager (RevMan) software and reported according to Cochrane Collaboration criteria. Risk ratios and corresponding 95% confidence intervals were calculated for dichotomous data while the numbers needed to treat were not calculated for each study but only for the summary risk ratio from the meta-analysis. The mean difference and 95% confidence intervals were calculated for the continuous data.

Dealing with missing data

The original investigators of the studies with missing data were contacted to request the missing data or identify the reason for missing data. However, due to the absence of individual participant data, it was impossible to undertake an intention-to-treat analysis.

Assessment of heterogeneity

Although assessment of heterogeneity was planned, Cochran's test for heterogeneity was not appropriate as no meta-analyses, combining more than one study, were undertaken.

Assessment of reporting biases

Although assessment of reporting biases was planned, it was not appropriate to use funnel plots to assess publication bias along with the statistical methods described by Egger 1997, because no meta-analyses to combine studies were able to be undertaken due to heterogeneity in study design.

Data synthesis

Meta-analyses were planned, but they were not possible because the included studies involved a variety of interventions. For the included trials, mean differences (MD) with 95% confidence intervals were calculated for all clinically important outcomes. The fixed-effect model was used.

Subgroup analysis and investigation of heterogeneity

Subgroup analysis was proposed for different age groups. However, there were insufficient trials to undertake it.

Sensitivity analysis

Although sensitivity analysis was planned to examine the effect of the quality assessment items on the assessment of the overall estimates of effect, this could not be done since no meta-analyses were undertaken.

Further analyses are expected in future updates of this review with reports that fulfil the inclusion criteria.

RESULTS

Description of studies

See: Characteristics of included studies; Characteristics of excluded studies; Characteristics of studies awaiting classification; Characteristics of ongoing studies.

Results of the search

The search identified 365 publications of which 342 were excluded after reviewing the title and/or abstract. Full articles were obtained for the remaining 23 studies. From the full articles, six publications proved ineligible and were excluded. Of the remaining 17

publications, four reports were abstracts of trials. Seventeen corresponding authors were contacted for further information concerning 17 reports. Seven of these publications were excluded, mainly because they were confirmed not to be randomised controlled trials (RCTs) by the corresponding authors, two are pending further information from the authors and are awaiting classification, and one has been identified as an ongoing study after contacting the corresponding author and after discussing the study among the review team and with the Cochrane Oral Health Group. Therefore, seven RCTs (Cobb 1998; Evans 1998; Fernandes 1998; Jones 1992; O'Brien 1990; Pandis 2009; West 1995) fulfilled all the criteria for inclusion. For details of the studies that were examined and the reasons for inclusion or exclusion please *see* Characteristics of included studies and Characteristics of excluded studies.

Included studies

Design

All of the seven included studies were parallel group studies. In the study by Cobb 1998, participants were firstly allocated to 0.018 or 0.022 inch fixed orthodontic braces without randomisation, and then patients in each block were allocated randomly to three groups of arch wires. In four of the trials (Evans 1998; Fernandes 1998; Jones 1992; West 1995), upper and/or lower dental arches were randomly allocated to either an experimental or control arch wire while in the study by O'Brien 1990, only upper arches were included and in the study by Pandis 2009, only lower arches were investigated.

Sample sizes

The sample sizes ranged from 40-128 patients or 40-158 arches. Four of the seven studies undertook an a priori sample size calculation. Three of these planned the sample sizes on the basis of previous (pilot) researches in order to detect significant differences between two parallel groups (Evans 1998; Jones 1992; West 1995) and one calculated the sample size based on a time-to-event analysis to detect a 45% difference (Pandis 2009). Interestingly, the sample size was not consistent throughout the study report of Cobb 1998 and the number of either patients or arches allocated to each intervention group was not reported by Evans 1998.

Setting

Of the seven included trials, four were conducted in the UK (Evans 1998; Jones 1992; O'Brien 1990; West 1995), one in the USA (Cobb 1998), one in Norway (Fernandes 1998) and one in Greece (Pandis 2009). Three studies had more than one publication (Jones 1992; O'Brien 1990; West 1995). Two of the trials (Cobb 1998; Evans 1998) received external funding, while five did not.

Participants

Six of the included studies had clear inclusion/exclusion criteria for the selection of participants, except O'Brien 1990. All the included studies reported participants' ages, with only one trial including adults (older than 18 years) (Cobb 1998). Furthermore, the gender mix was only stated in three trials (Fernandes 1998; Pandis 2009; West 1995).

Interventions

One study compared 0.016 inch ion-implanted A-NiTi wire, 0.016 inch A-NiTi wire and 0.0175 inch multistrand steel wire (Cobb 1998); one study compared 0.016x0.022 inch medium force active M-NiTi wire, 0.016x0.022 inch graded force active M-NiTi wire and 0.0155 inch multistrand stainless steel wire (Evans 1998); one study compared 0.016 inch superelastic NiTi wire with 0.016 inch NiTi wire (O'Brien 1990); one study compared 0.014 inch superelastic NiTi wire with 0.0155 inch multistrand steel wire which is also called multiple flex steel (West 1995); one study compared 0.014 inch superelastic NiTi wire with 0.014 inch NiTi wire (Fernandes 1998); one study compared 0.014 inch superelastic heavy Japanese NiTi wire with 0.015 inch multistrand steel wire (Jones 1992); and one study compared 0.016 inch CuNiTi wire with 0.016 inch NiTi wire (Pandis 2009).
No trial was identified that examined the effectiveness of Beta-Ti wires.

Outcomes

Of the outcomes proposed in this systematic review, four were evaluated in the included studies.
(1) The alignment rate per month (Cobb 1998; Evans 1998; O'Brien 1990; West 1995).
(2) Time to the next/working arch wire (Cobb 1998; Evans 1998).
(3) Time to alignment (Pandis 2009).
(4) The intensity of pain experienced by patients (Fernandes 1998; Jones 1992).
The amount of root resorption was not reported in any included studies.

Excluded studies

See Characteristics of excluded studies.

Risk of bias in included studies

The assessments for the four main methodological quality items are shown in Additional Table 1. A study was assessed to have an overall high risk of bias if it did not record a 'Yes' in three or more of the four main categories, moderate if two out of the four categories did not record a 'Yes' and low if sequence generation, outcome assessment blinding and completeness of follow-up were

considered adequate. Two studies (O'Brien 1990; Pandis 2009) recorded a 'Yes' in all four major categories.

Allocation

Although all of the seven included studies were RCTs, the method of randomisation was considered adequate for only three trials (O'Brien 1990; Pandis 2009; West 1995) after examination of the publications and further contact with the authors. One used a random number generator (O'Brien 1990); one used random permuted blocks (Pandis 2009); and one used a predetermined random allocation scheme (West 1995). Two trials used opaque envelopes for allocation concealment (O'Brien 1990; Pandis 2009). The method of randomisation and allocation concealment was unclear for the remaining four publications (Cobb 1998; Evans 1998; Fernandes 1998; Jones 1992). Three studies (Cobb 1998; Jones 1992; Pandis 2009) carried out a comparison to assess comparability of the experimental groups at baseline.

Blinding

Blinding for outcome assessment was considered adequate in two trials (O'Brien 1990; Pandis 2009) after contact with the authors.

Incomplete outcome data

The reporting of withdrawals was considered clear for all seven trials. In four trials there were no drop outs (Fernandes 1998; O'Brien 1990; Pandis 2009; West 1995). In three trials the number of drop outs and the reasons for withdrawals were clearly described, however, no intention-to-treat analyses were undertaken (Cobb 1998; Evans 1998; Jones 1992).

Selective reporting

In the report by O'Brien 1990, the pain data that were recorded during the investigation were not reported since the researchers found these not to be sufficiently reliable for analysis.

Effects of interventions

See: **Summary of findings for the main comparison**; **Summary of findings 2**; **Summary of findings 3**; **Summary of findings 4**

0.016 inch ion-implanted A-NiTi wire (Sentalloy) versus 0.016 inch A-NiTi wire (Sentalloy) versus 0.0175 inch multistrand stainless steel wire (Wildcat)

(Cobb 1998)

This trial, involving 123 participants and 155 dental arches, compared three intervention groups for 12 months. The speed of initial tooth alignment was investigated. Patients were seen at a 4-week interval after insertion of the assigned initial arch wires and direct measurements were repeated monthly, until the irregularity index dropped to 2 mm or less. Then, the initial arch wires were changed. The alignment rate was assessed by the reduction in the irregularity index as a function of time (mm/month) and the time to next/working arch wire was assessed by the time for alignment to the 2 mm irregularity. No statistically significant difference between the arch wire types was found. However, no definite outcome data for each intervention group were reported. In contrast to the study by West 1995, randomisation in this study was at the patient level while the treatment effect was studied at the arch level. Thus, a "unit of analysis error" occurred (Whiting-O'Keefe 1984).

0.016x0.022 inch medium force active M-NiTi wire (Titanium Heat Memory Wire) versus 0.016x0.022 inch graded force active M-NiTi wire (Bioforce Sentalloy) versus 0.0155 inch multistrand stainless steel wire (Dentaflex)

(Evans 1998)

This trial, involving 51 participants and 98 dental arches, compared three intervention groups for 8 weeks. The speed of initial tooth alignment was investigated. Patients were seen at a 4-week interval as well and alginate impressions of the dental arches were taken repeatedly, until 8 weeks. The alignment rate was assessed by the changes of contact point distances of the anterior, the posterior and the whole arch in two- and three-dimensional measurements. The time to next/working arch wire was measured by the time span for the placement of each investigated initial arch wire. There was no statistically significant difference between the intervention groups.

0.016 inch superelastic NiTi wire (Titanol) versus 0.016 inch NiTi wire (Nitinol) (Comparison 1)

(O'Brien 1990)

This trial, involving 40 participants and 40 maxillary dental arches, compared two intervention groups for a mean duration of 35 days. The speed of initial tooth alignment was assessed by three-dimensional contact point movements of the upper anterior arches. There was no statistically significant difference between these two intervention groups.

0.014 inch superelastic NiTi wire (NiTi) versus 0.0155 inch multistrand stainless steel wire (Dentaflex)

(West 1995)

This trial, involving 62 participants and 74 dental arches, compared two intervention groups for 6 weeks. The unit of analysis in this study was the dental arch. Arches were individually randomised to one of the two intervention groups, and the outcome measurement for each arch was collected and analysed. The speed of initial tooth alignment was assessed by three-dimensional contact point movements of the anterior and the whole dental arches

using the index of tooth alignment (ITA). The main difference, in comparison to Little's irregularity index (Little 1975), is that the positions of the anatomic contact points are digitised in three dimensions and the process may be extended to the full dental arch. The effects of the two arch wires were compared by an analysis of covariance on the means of triplicate log ITA scores. The superelastic NiTi wire was found to produce improved alignment in comparison to the multistrand steel wire in the mandibular labial segment. However, the outcome data for each intervention group were not reported in this publication. Instead, only the geometric mean ratios of the malalignment index (ITA) for NiTi/multistrand steel arch wires were reported.

0.016 inch CuNiTi wire (Ormoco) versus 0.016 inch NiTi wire (ModernArch)

(Pandis 2009)

This trial, involving 60 participants and 60 mandibular dental arches, compared two intervention groups. The outcome was the time to alignment, determined as the time from first arch wire placement to alignment completion of the six mandibular anterior teeth. All participants were followed monthly for a maximum of 6 months; for patients not aligned after 6 months of active treatment, the remaining crowding was recorded. There was no statistically significant difference in crowding alleviation between the two types of wires (129.4 versus 121.4 days; hazard ratio 1.3; $P > 0.05$).

0.014 inch superelastic NiTi wire (Sentalloy) versus 0.014 inch NiTi wire (Nitinol) (Comparison 2)

(Fernandes 1998)

This trial, involving 128 participants and 128 dental arches, compared two intervention groups. The outcome was the intensity of pain/discomfort experienced by patients during the initial alignment stage of treatment for 7 days, evaluated by VAS scores and the consumption of analgesics. The results showed no statistically significant difference in the pain intensity when the two initial arch wires were compared.

0.014 inch superelastic NiTi wire (heavy Japanese NiTi) versus 0.015 inch multistrand stainless steel wire (Twistflex) (Comparison 3)

(Jones 1992)

This study had three stages, involving two intervention groups and a control group. Only part of this study, stage II, involving 42 participants, was evaluated in this Cochrane review. The outcome was also the intensity of pain/discomfort experienced by patients over 15-day period after placement of an initial arch wire, measured by VAS scores and consumption of analgesics. Though only part of the outcome data (1 to 7 days) were reported in detail, most other studies have shown that pain levels have returned to normal at 6 or 7 days after the initial wires are placed (Erdinc 2004; Firestone 1999; Ngan 1989; Scheurer 1996), which indicates that any differences in pain/discomfort between intervention groups are likely to be minimal after 7 days. Therefore, the lack of the remaining VAS data is unlikely to introduce any substantial bias. There was no statistically significant difference in pain response between the two initial arch wires.

Two studies (Fernandes 1998; Jones 1992) did not address the primary outcomes of this review, however the secondary outcome of the intensity of pain experienced by patients was investigated.

ADDITIONAL SUMMARY OF FINDINGS *[Explanation]*

0.016 inch CuNiTi wire compared with 0.016 inch NiTi wire for initial alignment of crooked teeth

Patient or population: Patients with full arch fixed orthodontic appliances
Settings: Greece
Intervention: 0.016 inch CuNiTi wire
Comparison: 0.016 inch NiTi wire

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No of Participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	0.016 inch CuNiTi wire	0.016 inch NiTi wire				
Time to alignment of the lower anterior dental arches (days) 6 months	The mean time to alignment in 0.016 inch CuNiTi wire group was 129.4 days	The mean time to alignment in 0.016 inch NiTi wire group was 121.4 days	Not estimable	60 (1 study)	+++O moderate	Not generalised findings

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: Confidence interval; RR: Risk Ratio.

GRADE Working Group grades of evidence
High quality: Further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: We are very uncertain about the estimate.

0.014 inch superelastic NiTi wire compared with 0.014 inch NiTi wire for initial alignment of crooked teeth

Patient or population: Patients with full arch fixed orthodontic appliances
Settings: Norway
Intervention: 0.014 inch superelastic NiTi wire
Comparison: 0.014 inch NiTi wire

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No of Participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	0.014 inch NiTi wire	0.014 inch superelastic NiTi wire				
Pain intensity (2nd day) Visual analogue scale (VAS) from 0-no pain, to 100mm-maximum pain	The mean VAS sore in 0.014 NiTi group was 36	The mean VAS score in 0.014 superelastic NiTi group was 37.2	1.20 [-9.63, 12.03]	128 (1 study)	+++O moderate	Limitations in the design and implementation
Pain intensity (3rd day) Visual analogue scale (VAS) from 0-no pain to 100mm-maximum pain	The mean VAS score in 0.014 NiTi group was 24.8	The mean VAS score in 0.014 superelastic group was 28.8	4.00 [-4.91, 12.91]	128 (1 study)	+++O moderate	Limitations in the design and implementation
Pain intensity (4th day) Visual analogue scale (VAS) from 0-no pain to 100mm-maximum pain	The mean VAS score in 0.014 NiTi group was 16.7	The mean VAS score in 0.014 superelastic group was 18.3	1.60 [-5.68, 8.88]	127 (1 study)	+++O moderate	Limitations in the design and implementation
Pain intensity (5th day) Visual analogue scale (VAS) from 0-no pain to 100mm-maximum pain	The mean VAS score in 0.014 NiTi group was 11.4	The mean VAS score in 0.014 superelastic group was 12.7	1.30 [-4.32, 6.92]	126 (1 study)	+++O moderate	Limitations in the design and implementation

Pain intensity (6th day) Visual analogue scale (VAS) from 0-no pain to 100mm-maximum pain	The mean VAS score in 0.014 NiTi group was 8.8	The mean VAS score in 0.014 superelastic group was 9.3	-0.50 [-5.39, 4.39]	125 (1 study)	+++O moderate	Limitations in the design and implementation
Pain intensity (7th day) Visual analogue scale (VAS) from 0-no pain to 100mm-maximum pain	The mean VAS score in 0.014 NiTi group was 6.7	The mean VAS score in 0.014 superelastic group was 7.1	0.40 [-3.81, 4.61]	124 (1 study)	+++O moderate	Limitations in the design and implementation

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: Confidence interval; RR: Risk Ratio.

GRADE Working Group grades of evidence
High quality: Further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: We are very uncertain about the estimate.

0.014 inch superelastic NiTi compared with 0.015 inch multistrand stainless steel for initial alignment of crooked teeth

Patient or population: Patients with full arch fixed orthodontic appliances
Settings: UK
Intervention: 0.014 inch superelastic NiTi wire
Comparison: 0.015 inch multistrand stainless steel wire

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No of Participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	0.015 inch multistrand stainless steel wire	0.014 inch superelastic NiTi wire				
Pain intensity (1st day) Visual analogue scale (VAS) from 0-no pain to 100mm-maximum pain	The mean VAS score in 0.015 SS group was 23.7	The mean VAS score in 0.014 superelastic NiTi group was 29	5.30 [-7.74, 18.34]	42 (1 study)	++00 low	Limitations in the design and implementation; imprecision of results
Pain intensity (2nd day) Visual analogue scale (VAS) from 0-no pain to 100mm-maximum pain	The mean VAS score in 0.015 SS group was 25	The mean VAS score in 0.014 superelastic NiTi group was 19.6	-5.40 [-19.22, 8.42]	42 (1 study)	++00 low	Limitations in the design and implementation; imprecision of results
Pain intensity (3rd day) Visual analogue scale (VAS) from 0-no pain to 100mm-maximum pain	The mean VAS score in 0.015 SS group was 20.6	The mean VAS score in 0.014 superelastic NiTi group was 12.6	-8.00 [-18.22, 2.22]	42 (1 study)	++00 low	Limitations in the design and implementation; imprecision of results
Pain intensity (4th day) Visual analogue scale (VAS) from 0-no pain to 100mm-maximum pain	The mean VAS score in 0.015 SS group was 11.0	The mean VAS score in 0.014 superelastic NiTi group was 5.5	2.90 [-1.05, 6.85]	42 (1 study)	++00 low	Limitations in the design and implementation; imprecision of results

Pain intensity (5th day) Visual analogue scale (VAS) from 0-no pain to 100mm-maximum pain	The mean VAS score in 0.015 SS group was 2.6	The mean VAS score in 0.014 superelastic NiTi group was 4.1	1.50 [-1.82, 4.82]	42 (1 study)	++OO low	Limitations in the design and implementation; imprecision of results
Pain intensity (6th day) Visual analogue scale (VAS) from 0-no pain to 100mm-maximum pain	The mean VAS score in 0.015 SS group was 1.2	The mean VAS score in 0.014 superelastic NiTi group was 2.9	1.70 [-1.26, 4.66]	42 (1 study)	++OO low	Limitations in the design and implementation; imprecision of results
Pain intensity (7th day) Visual analogue scale (VAS) from 0-no pain to 100mm-maximum pain	The mean VAS score in 0.015 SS group was 0.5	The mean VAS score in 0.014 superelastic NiTi group was 1.2	0.70 [-0.57, 1.97]	42 (1 study)	++OO low	Limitations in the design and implementation; imprecision of results
Pain intensity (over 14 days) Visual analogue scale (VAS) from 0-no pain to 100mm-maximum pain	The mean VAS score in 0.015 SS group was 6.1	The mean VAS score in 0.014 superelastic NiTi group was 5.7	-0.40 [-3.36, 2.56]	42 (1 study)	++OO low	Limitations in the design and implementation; imprecision of results

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: Confidence interval; RR: Risk Ratio; SS: Stainless steel

GRADE Working Group grades of evidence
High quality: Further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: We are very uncertain about the estimate.

DISCUSSION

Summary of main results

The objective of the present study was to evaluate the effects of initial arch wires for alignment of teeth with fixed orthodontic appliances, using the systematic review method. Seven randomised controlled clinical trials (RCTs) satisfied the inclusion criteria and were included. The available evidence indicated that there was no statistically significant difference in the effects of initial arch wires in terms of the speed of initial tooth alignment and the intensity of pain experienced by patients during the initial alignment stage of treatment. However, in view of the general poor quality of the included trials, these results should be viewed with caution. No information was available to answer whether there was significant difference in the root resorption accompanying initial tooth movement among arch wire types.

Full details of the main findings of this review are included in Summary of findings for the main comparison; Summary of findings 2; Summary of findings 3 and Summary of findings 4.

Overall completeness and applicability of evidence

Among the seven included trials, four aimed to assess the speed of initial tooth alignment by comparing the alignment rate per month (Cobb 1998; Evans 1998; O'Brien 1990; West 1995), the time to next/working arch wire (Cobb 1998; Evans 1998), and the time to alignment (Pandis 2009). Another two studies reported the intensity of pain experienced by patients during the initial alignment stage of treatment (Fernandes 1998; Jones 1992). There were no RCTs investigating the amount of root resorption that occurs with initial tooth movement.

Quality of the evidence

This review has included seven RCTs and 517 participants. Most of the studies indicated that there were no statistically differences in the effects of initial arch wires in terms of the speed of initial alignment and the intensity of pain during the initial alignment phase of treatment. However, it is important to note that only two studies included in this review (O'Brien 1990; Pandis 2009) met all the explicit criteria used to assess the study validity and were rated as at low risk of bias. We tried to contact all the authors of the included studies for more information but only one replied and offered further information (O'Brien 1990). However, though more detail was provided by personal email, considering its lack of clear inclusion/exclusion criteria for participants selection and small sample size in O'Brien 1990, the quality of this evidence was ranked moderate. Only one study (Cobb 1998) included participants older than 18 years. Though there is no convincing evidence that the rate of tooth alignment in adults is biologically slower than in younger patients. Therefore, all potential patients, including adults should be included, in order that the findings from investigations are more generalisable. In addition, only four studies (Evans 1998; Jones 1992; Pandis 2009; West 1995) had carried out an a priori sample size calculation. When future studies are planned, greater consideration should be given to study design in order to reduce bias and the number of participants required to demonstrate a statistically (and clinically) significant difference, should this actually exist. For example, the data used for power calculation should be the primary outcomes - i.e. amount of tooth movement/root resorption. Since there were no data reported in any of the studies in relation to root resorption, then this can only be based on tooth movement. Using the data from O'Brien 1990, we conducted a two-sample calculation using a sample size calculator (www.dssresearch.com/toolkit/sscalc/size_a2.asp). Using the mean contact point movements for both wires tested (1.7 (1.15) mm and 1.42 (0.79) mm) gives a sample size of 154 in each group. The included studies have considerable heterogeneity and future studies should consider standardisation of study design to make results comparable. This would involve factors such as appliance system, slot size and the ligature methods, which may have been important confounders among the studies that were included in this review. Only three studies described the appliances they used (Cobb 1998; Jones 1992; Pandis 2009) and only three studies standardised the ligation method (Cobb 1998; Fernandes 1998; Pandis 2009). In addition, bracket debonding may have also influenced the results if rebonding was not performed soon after the bracket became debonded. Unfortunately, only one study considered this variable (Evans 1998). For investigators conducting future studies in this field, a stratified blocked randomisation (Cobb 1998) should be employed, with details about the appliance system and the ligature method among other parameters should be clearly detailed in the report.

When examining the effects of initial arch wires for alignment of teeth with fixed orthodontic appliances, three aspects should be considered. Firstly, whether there is any difference in the speed of initial tooth alignment when comparing different arch wires. Three studies (Cobb 1998; O'Brien 1990; Pandis 2009) used the irregularity index firstly described by Little (Little 1975). This index (as originally described) addresses the sum of the five contact point displacements for the mandibular anterior teeth, regardless of any irregularities in the buccal segments. West et al (West 1995) and Evans et al (Evans 1998) used the index of tooth alignment (ITA), which includes an assessment of the whole dental arch. An assessment of the contact point discrepancies for the whole arch is a useful outcome measure, especially when crowding/irregularities occur in the canine, premolar and molar regions. There are two main methods of recording the amount of crowding: direct measurement in the mouth with a digital vernier calliper (Cobb 1998; Pandis 2009) and indirect measurement on stone casts in three dimensions with instruments such as the reflex metrograph. Both methods are associated with drawbacks. When using di-

rect measurement, the examiner(s) will require calibration at the start and regular recalibration throughout the trial period, to ensure consistency of the measurements. A second problem with direct measurements is blinding/masking. To reduce bias the examiner should be blinded/masked to group allocation at the time of recording, which may complicate the operation of the trial. Indirect measurement on casts can resolve this problem when the casts are measured in a random order and the assessors are blinded/masked to allocation. However, indirect measurement in three dimensions required specialised instruments, such as the Reflex Metrograph (O'Brien 1990) and the Reflex Microscope (Evans 1998; West 1995), which adds to the cost of a clinical study. Another problem with three-dimensional indirect measurements is that of identifying the fiducial points on each cast, which is important for ascertaining adequate reproducibility of the measurements. Despite these problems, four studies were associated with an acceptable method error (Cobb 1998; Evans 1998; O'Brien 1990; West 1995).

The second aspect that should be considered is whether there is any difference in the amount of root resorption associated with initial tooth movement. Unfortunately, this aspect has not been investigated by any RCTs up to now. Root resorption is one of the most serious side-effects of orthodontic treatment and has been well-known for many years (Linge 1983; Rudolph 1940; Weiland 2003). It is thought that the type and level of force are among the factors influencing the extent of root resorption. Stainless steel wires generate a high but rapidly declining force after ligation of an arch wire, whereas superelastic wires deliver a constant force over an extended period of the deactivation range (Miura 1986). Therefore, further evaluation of initial arch wires should consider this potentially serious side-effect of orthodontic treatment.

Thirdly, the potential for any difference in the intensity of pain experienced by patients during the initial alignment stage of treatment with different arch wires should be evaluated. Two studies (Fernandes 1998; Jones 1992) used a 100 mm visual analogue scale (VAS) and the consumption of analgesics to evaluate pain intensity. A 100 mm VAS is an ordinal scale of 0 (no pain) to 100 (maximum pain) and has been widely used in pain evaluation.

One variable that was not standardised among the studies was the length of time over which the initial arch wires were studied. The study by Cobb 1998 took 12 months to investigate the initial alignment rate, which was longer than is required in routine clinical orthodontics. The studies by O'Brien 1990 and West 1995 only involved around 1 month of data collection, which was paradoxically short, but as these studies only observed the amount of tooth movement in the first month of treatment but not the mean rate of initial alignment, this is appropriate. Evans et al (Evans 1998) used an observation time of 8 weeks, which was too short for "time to the next/working arch wire". Meanwhile Pandis et al (Pandis 2009) observed their subjects for 6 months, which was an appropriate duration for "time to alignment". Fernandes 1998 assessed patients over 7 days whilst Jones et al (Jones 1992) evaluated patients over 15 days for pain intensity, which were appropriate time periods (Erdinc 2004; Firestone 1999; Ngan 1989; Scheurer 1996). Ideally, the duration of studies should be standardised with a longer observation period for full alignment. Ideally, a standardised duration would be appropriate and a longer observation period for full alignment would be more appropriate on a clinical basis. Long study time period investigations would be needed in regards with the amount of tooth movement, root resorption and pain intensity.

In addition, an economic analysis should also be considered in future studies of initial aligning arch wires. The cost of arch wires, the amount of time required for ligation, the overall number of appointments (including any additional appointments required for breakages, e.g. wire fracture) and also the type of orthodontic care provider as overheads may be more expensive in hospital settings in comparison to practice-based case, will unavoidably influence the selection of initial arch wires. However, there were no economic data reported by the RCTs that were included in this review.

Due to the inherent bias in most of the study designs, the information from those included studies in this review should be interpreted with caution. From the limited information available, only broad generalisations are possible.

Potential biases in the review process

A sensitive search strategy was used for this review. Every effort was made to identify all relevant studies. No studies were excluded due to language. We tried to contact authors of studies on initial arch wires for alignment of teeth with fixed orthodontic appliances by email and postal mail to identify unpublished studies or additional information about their studies. However, only a few authors (O'Brien, Weiland, Jones, Bondemark) replied. It was not possible to include further studies due to the insufficient data contained in the reports.

Data collection and analysis were done by two review authors independently, and any disagreement between review authors was resolved by discussion or the assistance of the Cochrane Oral Health Group to minimise/exclude bias during the review process.

Agreements and disagreements with other studies or reviews

Only one published systematic review (Riley 2009) was identified. The review of Riley 2009 only focused on one outcome "objective measurement of alignment/irregularity" to assess the effectiveness of arch wires for alignment, while the amount of root resorption along with tooth movement and the intensity of pain experienced by patients during the initial alignment stage of treatment were also evaluated in our review. Seven studies were included in Riley 2009, of which five (Cobb 1998; Evans 1998; Jones 1992; O'Brien 1990; West 1995) were included, and the other two (Dalstra

2004; Pandis 2007) were excluded in our review. Two studies (Fernandes 1998; Pandis 2009) were included in our review , while they were not included in Riley 2009. Riley 2009 included both randomised clinical trials and controlled clinical trials, while only randomised clinical trials were included in our Cochrane review. The data extraction, assessment of the evidence quality and the authors' conclusion of the two reviews were mainly in accordance between the two reviews. It should be noted that due to a lack of homogeneity among the included studies, meta-analyses could not be undertaken in either reviews.

AUTHORS' CONCLUSIONS

Implications for practice

There is some evidence to suggest that there is no difference between the rate of alignment or pain experienced by patients when using one initial aligning arch wire over another. However, in view of the general poor quality of the included trials, these results should be interpreted with caution.

Implications for research

In view of the quality issues of the trials that were identified in this systematic review, it is difficult to draw definitive conclusions. This review suggests a need for more well designed randomised controlled clinical trials, in order to determine which initial arch wire is most effective. However, in designing future trials, the following need to be considered.

- Clear inclusion/exclusion criteria should be set.
- An a priori sample size calculation should be carried out.
- Adult patients should be included in trials to increase the generalisability of the results.
- Treatment, except for the intervention, should be as similar as possible among the trial participants and should be clearly described.
- Consideration needs to be given to standardised measurements for evaluating tooth movement.
- Adverse effects, such as root resorption should be reported.
- Economic data such as costs or cost-effectiveness of each type of arch wire would also be helpful.
- Reports on clinical trials would be improved by following the guidelines produced by the CONSORT Group (Moher 2005) to ensure that all relevant information is provided.

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* *Indicates the major publication for the study*

CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

Cobb 1998

Methods	RCT; 3 parallel groups. 12-month period.
Participants	126 participants (3 drop outs), 158 arches with pre-treatment incisor irregularity > 5.0 mm (3 drop outs) M/F not stated. Age ranged 10-30 years. Setting: The graduate clinic or faculty practice at the University of North Carolina
Interventions	13 blocks of 9 patients were allocated to fixed appliance of 0.018 (6 blocks) or 0.022 (7 blocks) inch slot size and patients in each block were allocated randomly to 3 kinds of arch wires as follows Gp1: 0.016 inch Ion-implanted A-NiTi, Sentalloy implanted by Spire Corporation, with mean age of 15.2 years (sd = 3.8). Fixed Edgewise appliance Gp2: 0.016 inch A-NiTi, Sentalloy, GAC, with mean age of 17.3 years (sd = 6.7). Fixed Edgewise appliance Gp3: 0.0175 inch 3-strand steel, Wildcat, GAC, with mean age of 16.3 years (sd = 5.1) . Fixed Edgewise appliance The assigned arch wire was placed and tied into the brackets with elastomeric ligatures. The patients were seen at 4-week intervals and measurements were repeated, until the irregularity index dropped to 2 mm or less
Outcomes	Primary outcome measure: Alignment rate assessed with the reduction in the irregularity index as a function of time Secondary outcome measure: Time to next/working arch wire assessed by the time for alignment to the 2 mm irregularity
Notes	Stratification: Bracket slot size used as a stratification factor Randomisation was at the subject level while outcome was studied at the dental arch level Sample size was not consistent. No definite outcome data of each intervention group reported Funding: In part by a contract from Spire Corporation, under the terms of an SBIR (small business initiative) grant from the National Institute of Dental Research Further information was requested from the authors but there was no reply

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Unclear	Not described.

Cobb 1998 (*Continued*)

Incomplete outcome data addressed? All outcomes	Unclear	The number of participants reported not consistent. Clear information on reasons for withdrawals but no intention-to-treat analysis

Evans 1998

Methods	RCT; 3 parallel groups. 8-week observation period.
Participants	56 consecutive participants undergoing 2-arch fixed appliance therapy (5 drop outs), 112 upper or lower arches (14 drop outs) M/F not stated. Age < 18 years.
Interventions	Gp1: 0.016x0.022 inch medium force active M-NiTi, Titanium Heat Memory Wire/ American Orthodontics Gp2: 0.016x0.022 inch graded force active M-NiTi, Bioforce Sentalloy/GAC Inc Gp3: 0.0155 inch multistranded stainless steel, Dentaflex/Dentarium The arch wire was ligated as fully as possible into the brackets with the clinicians preferred method (usually elastomeric rings), and was fully religated at the routine follow-up appointment at 4 weeks
Outcomes	Primary outcome measure: Tooth movement assessed from dental casts with 3- and 2-dimensional intertooth (contact) point movement within the anterior, posterior and whole arch from before and after 4 and 8 weeks treatment, using a reflex microscope Secondary outcome measure: Time to next/working arch wire assessed by the time span in days for the use of each wire type
Notes	Type and slot size of fixed appliance unclear. Sample size calculated. Funding: Welsh Scheme for the Development of Health and Social Research No more information was obtained from the authors.

Risk of bias

Item	**Authors' judgement**	**Description**
Allocation concealment?	Unclear	Quote: "Allocation was predetermined and randomized."
Incomplete outcome data addressed? All outcomes	Unclear	Number of either patients or arches allocated to each intervention group not known. Clear information on reasons for withdrawals but no intention-to-treat analysis

Fernandes 1998

Methods	RCT; 2 parallel groups. 7 days follow-up.
Participants	128 consecutive participants undergoing fixed appliance therapy M/F 56/72. Mean age 12.5 years (median = 12 years; range = 9-16 years). Setting: The Department of Orthodontics at Oslo University School of Dentistry and 2 private practices in Oslo, Norway
Interventions	Gp1: 0.014 inch Superelastic NiTi alloy, Sentalloy, Light, GAC International Inc. Central Islip, NY, USA. M/F 28/37 and mean age of 12.6 years (median = 12 years; range = 10-16 years) (65 participants) Gp2: 0.014 inch NiTi archwire, Nitinol, Unitek, Monrovia, CA, USA. M/F 28/35 and mean age of 12.5 years (median = 12 years; range = 9-16 years) (63 participants) The brackets used, the placement of brackets and arch wires were standardised
Outcomes	Secondary outcome measure: Pain assessed with VAS (100 mm) recorded every hour for the first 11 hours following the placement of the initial arch wire and once every day at the same time point for the following 6 days Consumption of analgesics reported by patients.
Notes	Type and slot of fixed appliance unclear. Funding: Not stated. The authors could not be contacted.

Risk of bias

Item	**Authors' judgement**	**Description**
Allocation concealment?	Unclear	Not stated.
Incomplete outcome data addressed? All outcomes	Unclear	No drop outs reported. 63 missing pain scores in Sentalloy group and 86 in Nitinol group. Unclear information on reason for missing data

Jones 1992

Methods	RCT; 2 parallel groups. Duration of study unclear.
Participants	45 consecutive participants with a full arch edgewise fixed appliance (3 drop outs) M/F not stated. Age range 9.42-16.83 years. Setting: The Orthodontic Clinic at the University of Wales College of Medicine
Interventions	Gp1: 0.014 inch superelastic heavy Japanese NiTi, Sentalloy, GAC International Inc., Central Islip, NY. Mean age of 13.29 years. 0.018x0.030 inch standard (triple control)

Jones 1992 (*Continued*)

	pre-adjusted bioprogressive brackets (RockyMountain Orthodontics, Denver, Colorado) (21 arch wires) Gp2: 0.015 inch multistrand steel, Twistflex, Unitek Corp., Monrovia, Calif. Mean age of 13.17 years. 0.018x0.030 inch standard (triple control) pre-adjusted bioprogressive brackets (Rocky Mountain Orthodontics, Denver, Colorado) (21 arch wires)
Outcomes	Secondary outcome measure: Pain assessed with VAS score (100 mm) recorded at 9:00, 13:00, 17:00 and 21:00 every day over 15 days Pain after 24 hours assessed with questionnaire. Analgesics consumption.
Notes	Sample size calculated. Funding: Not stated. No more information was obtained from the authors.

Risk of bias

Item	Authors' judgement	Description
Adequate sequence generation?	Unclear	No description on sequence generation.
Allocation concealment?	Unclear	Not stated.
Incomplete outcome data addressed? All outcomes	Unclear	Clear information on reasons for withdrawals but no intention-to-treat analysis

O'Brien 1990

Methods	RCT; 2 parallel groups. Mean duration 35 days.
Participants	40 participants with routine Edgewise fixed appliance, 40 upper dental arches M/F not stated. Age ranged 11-17.25 years.
Interventions	Gp1: 0.016 inch superelastic NiTi, Titanol, Forestadent, Milton Keynes, UK. M/F 9/11, mean age of 12.95 years (sd = 3.2; range = 11-16.5 years) and mean duration of 34 days (sd = 2). Fixed Edgewise appliance Gp2: 0.016 inch conventional work hardened NiTi, Nitinol, Unitek Corp., Monrovia, California, USA. Mean age of 13.4 years (sd = 3.12; range = 11.5-17.25 years) and mean duration of 37 days (sd = 2). Fixed Edgewise appliance The arch wire was tied with ligatures into the identical Edgewise brackets with complete engagement where clinically possible
Outcomes	Primary outcome measure: Tooth movement assessed from dental casts with 3-dimensional intertooth (contact) point movement of the upper anterior arch from before treatment and subsequent appointment using Reflex Metrograph

O'Brien 1990 (*Continued*)

Notes	Funding: Not stated. The following completed data were acquired by personal communication: 1) the patients were followed to the second data collection stage at 35 days; 2) slot size of the bracket was probably 0.018 inch

Risk of bias

Item	Authors' judgement	Description
Adequate sequence generation?	Yes	Quote from personal email: "The sequence was generated by a random number generator." Comments: Probably done.
Allocation concealment?	Yes	Quote from personal email: "We put the arch wires into envelopes which were in a box on the clinic. The operator then took the next sequential arch wire." Comments: Probably done.
Blinding? Objective outcomes	Yes	Quote from personal email: "When I recorded the tooth movement from the study casts, I did not know which group the patients had been allocated, I was therefore blinded. The operators were not blinded to the wire." Comments: The outcome measurement was probably blinded.
Incomplete outcome data addressed? All outcomes	No	No drop outs reported.
Free of selective reporting?	No	Quote from personal email: "We attempted to record pain data but this was not sufficiently reliable for analysis." Comments: Not all of the study's pre-specified primary outcomes had been reported
Free of other bias?	No	No definite inclusion/exclusion criteria for participants selection. Small sample size

Pandis 2009

Methods	RCT; 2 parallel groups. Mean duration 6 months.
Participants	60 participants with the In-Ovation-R self-ligating bracket with a 0.022-in slot (GAC, Central Islip, NY); 60 lower dental arches M/F 23.3/76.7. Mean age 13.1 years (sd = 1.8). Setting: Private orthodontic office of the first author (Nikolaos Pandis)
Interventions	Gp1: 0.016-in CuNiTi 35°C wire, Ormco, Glendora, California. M/F 30/70, mean age of 13.4 years (sd = 1.8) Gp2: 0.016-in NiTi wire, ModernArch, Wyomissing, Pa., M/F 16.6/83.4, mean age of 12.8 years (sd = 1.7) All patients were bonded with the In-Ovation-R self-ligating bracket with a 0.022-in slot (GAC, Central Islip, NY). All first and second molars (when present) were bonded with bondable tubes (Speed System Orthodontics, Cambridge, Ontario, Canada). Bracket bonding, arch wire placement and treatment were performed by the same clinician
Outcomes	Secondary outcome measure: Time to alignment of the lower anterior dental arches, determined as the time from first arch wire placement to complete alignment The observation period ended after 6 months of intervention for all patients; for patients not aligned after 6 months of active treatment, the remaining crowding was recorded. The amount of crowding was assessed with the irregularity index described by Little. Measurements were made intraorally twice by the same clinician using a fine-tip digital caliber (Digimatic NTD 12-6-in C, Mitutoyo, Kanagawa, Japan), and the means of the 2 measurements were recorded
Notes	Sample size calculated. Funding: Not stated. Further information was requested from the authors but there was no reply

Risk of bias

Item	**Authors' judgement**	**Description**
Adequate sequence generation?	Yes	Quote: "Randomization was done using random permuted blocks of size 6." Comments: Probably done.
Allocation concealment?	Yes	Quote: "Opaque envelopes were used to allocate treatment. " Comments: Probably done.
Blinding? Objective outcomes	Yes	Quote: "Allocation of wires was concealed from the investigator and the participants during the observation period." Comments: The outcome measurement was probably blinded.

Pandis 2009 (*Continued*)

Incomplete outcome data addressed? All outcomes	No	No drop outs reported.

West 1995

Methods	RCT; 2 parallel groups. 6-week observation period.
Participants	62 consecutive participants with fixed appliances, 74 upper or lower arches M/F 1/2.
Interventions	Gp1: 0.014 inch superelastic NiTi, Armoco, Monrovia, Calif. Mean age of 15.4 years (sd = 5.2) and 42.7-day trial duration (sd = 3.2) (36 arch wires). Pre-adjusted fixed appliances Gp2: 0.0155 inch multiple flex steel wire, Dentaflex, Dentourium, Optident, Yorkshire, England. Mean age of 14.9 years (sd = 4.3) and 42.3-day trial duration (sd = 1.2) (38 arch wires). Pre-adjusted fixed appliances The wire was ligated as fully into each straight wire bracket as possible
Outcomes	Primary outcome measure: Tooth movement assessed from dental casts with 3-dimensional contact point movement from before treatment and subsequent appointment using Reflex Microscope (log_{10} transformed). A derived index of tooth alignment (ITA) was determined from the observation
Notes	Data of either intervention group not known. Slot size of the fixed appliance unclear. Sample size calculated. Funding: Not stated. No more information was obtained from the authors.

Risk of bias

Item	**Authors' judgement**	**Description**
Adequate sequence generation?	Yes	Quote: "The two arch wires types were randomly assigned to patients according to a predetermined random allocation scheme. " Comments: Probably done.
Allocation concealment?	Unclear	Not described.
Incomplete outcome data addressed? All outcomes	No	No drop outs reported.

Gp = group
M/F = male/female

RCT = randomised controlled trial
sd = standard deviation

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
AlQabandi 1999	Outcome data were not relevant to this review.
Dalstra 2004	Focus not on the different types of arch wire, but the changes in physical characteristics of the arch wire
Fleming 2009	Not a comparison of initial arch wires.
Fleming PS 2009	Not a comparison of initial arch wires.
Huffman 1983	Not an RCT.
Jones 1984	Case series.
Jones 1990	Not an RCT.
Kuftinec 1980	Not an RCT.
Lew 1988	Not an RCT.
Mandall 2006	Comparison of arch wire sequences and not individual arch wires
O'Brien 1987	Abstract; no additional information from main paper (O'Brien 1990) which is included.
Pandis 2007	Not a comparison of initial arch wires.
Weiland 2003	A CCT split-mouth study.

CCT = controlled clinical trial
RCT = randomised controlled trial

Characteristics of studies awaiting assessment *[ordered by study ID]*

Bloom 1998

Methods	Not known.
Participants	40 participants.

Bloom 1998 (*Continued*)

Interventions	Gp1: 0.019x0.025 inch Copper NiTi (Ormco). Gp2: 0.014 inch NiTi (Nitinol, Orthocare).
Outcomes	Primary outcome measure: Tooth movement assessed with irregularity index and the radial tooth distance scored using a travelling microscope
Notes	We have not yet found the full text of this study no matter how we tried. The research authors or the editors of the journal have not yet replied

Chekay 1999

Methods	Not known.
Participants	52 participants.
Interventions	Gp1: NiTi wires. Gp2: Stainless steel wires.
Outcomes	Primary outcome measure: Root resorption assessed by periapical radiographs
Notes	The full text of this study has not yet been found. The research authors or editors of journal have not yet replied either

Gp = group

Characteristics of ongoing studies *[ordered by study ID]*

Bernhold 2001

Trial name or title	Superelastic nickel-titanium heat-activated arch wires for tooth movement - a prospective randomised study of apical root resorption
Methods	RCT.
Participants	16 participants. M/F 5/9. Mean age 15.4 years.
Interventions	Gp1: Heat-activated superelastic NiTi. Gp2: Stainless steel.
Outcomes	Primary outcome measurement: Root resorption registered with index scores from 0 to 4 described by Levander and Malmgren, assessed from radiographic examination

Bernhold 2001 (*Continued*)

Starting date	Unclear.
Contact information	Professor Bondemark, one of the study authors, was contacted by email
Notes	The study has not yet been completed.

Gp = group
M/F = male/female
RCT = randomised controlled trial

DATA AND ANALYSES

Comparison 1. 0.016 inch superelastic NiTi wire versus 0.016 inch NiTi wire

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Alignment rate (contact point movement (mm))	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

Comparison 2. 0.014 inch superelastic NiTi wire versus 0.014 inch NiTi wire

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Pain intensity (VAS (2nd day))	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
2 Pain intensity (VAS (3rd day))	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
3 Pain intensity (VAS (4th day))	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
4 Pain intensity (VAS (5th day))	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
5 Pain intensity (VAS (6th day))	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
6 Pain intensity (VAS (7th day))	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

Comparison 3. 0.014 inch superelastic NiTi wire versus 0.015 inch multistrand stainless steel wire

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Pain intensity (VAS (1st day))	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
2 Pain intensity (VAS (2nd day))	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
3 Pain intensity (VAS (3rd day))	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
4 Pain intensity (VAS (4th day))	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
5 Pain intensity (VAS (5th day))	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
6 Pain intensity (VAS (6th day))	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
7 Pain intensity (VAS (7th day))	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
8 Pain intensity (VAS (over 14 days))	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

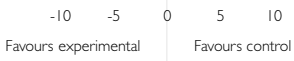
Analysis 1.1. Comparison 1 0.016 inch superelastic NiTi wire versus 0.016 inch NiTi wire, Outcome 1 Alignment rate (contact point movement (mm)).

Review: Initial arch wires for alignment of crooked teeth with fixed orthodontic braces

Comparison: 1 0.016 inch superelastic NiTi wire versus 0.016 inch NiTi wire

Outcome: 1 Alignment rate (contact point movement (mm))

Study or subgroup	0.016 superelastic NiTi N	Mean(SD)	0.016 NiTi N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Mean Difference IV,Fixed,95% CI
O'Brien 1990	20	1.7 (1.15)	20	1.42 (0.79)		0.28 [-0.33, 0.89]



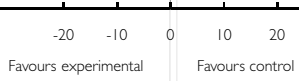
Analysis 2.1. Comparison 2 0.014 inch superelastic NiTi wire versus 0.014 inch NiTi wire, Outcome 1 Pain intensity (VAS (2nd day)).

Review: Initial arch wires for alignment of crooked teeth with fixed orthodontic braces

Comparison: 2 0.014 inch superelastic NiTi wire versus 0.014 inch NiTi wire

Outcome: 1 Pain intensity (VAS (2nd day))

Study or subgroup	0.014 superelastic NiTi N	Mean(SD)	0.014 NiTi N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Mean Difference IV,Fixed,95% CI
Fernandes 1998	65	37.2 (32.5)	63	36 (30)		1.20 [-9.63, 12.03]



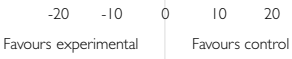
Analysis 2.2. Comparison 2 0.014 inch superelastic NiTi wire versus 0.014 inch NiTi wire, Outcome 2 Pain intensity (VAS (3rd day)).

Review: Initial arch wires for alignment of crooked teeth with fixed orthodontic braces

Comparison: 2 0.014 inch superelastic NiTi wire versus 0.014 inch NiTi wire

Outcome: 2 Pain intensity (VAS (3rd day))

Study or subgroup	0.014 superelastic NiTi N	Mean(SD)	0.014 NiTi N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Mean Difference IV,Fixed,95% CI
Fernandes 1998	65	28.8 (29.2)	63	24.8 (21.8)		4.00 [-4.91, 12.91]



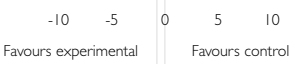
Analysis 2.3. Comparison 2 0.014 inch superelastic NiTi wire versus 0.014 inch NiTi wire, Outcome 3 Pain intensity (VAS (4th day)).

Review: Initial arch wires for alignment of crooked teeth with fixed orthodontic braces

Comparison: 2 0.014 inch superelastic NiTi wire versus 0.014 inch NiTi wire

Outcome: 3 Pain intensity (VAS (4th day))

Study or subgroup	0.014 superelastic NiTi N	Mean(SD)	0.014 NiTi N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Mean Difference IV,Fixed,95% CI
Fernandes 1998	65	18.3 (23.1)	62	16.7 (18.6)		1.60 [-5.68, 8.88]



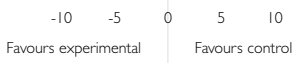
Analysis 2.4. Comparison 2 0.014 inch superelastic NiTi wire versus 0.014 inch NiTi wire, Outcome 4 Pain intensity (VAS (5th day)).

Review: Initial arch wires for alignment of crooked teeth with fixed orthodontic braces

Comparison: 2 0.014 inch superelastic NiTi wire versus 0.014 inch NiTi wire

Outcome: 4 Pain intensity (VAS (5th day))

Study or subgroup	0.014 superelastic NiTi N	Mean(SD)	0.014 NiTi N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Mean Difference IV,Fixed,95% CI
Fernandes 1998	65	12.7 (18.3)	61	11.4 (13.7)		1.30 [-4.32, 6.92]



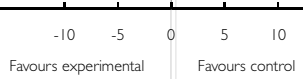
Analysis 2.5. Comparison 2 0.014 inch superelastic NiTi wire versus 0.014 inch NiTi wire, Outcome 5 Pain intensity (VAS (6th day)).

Review: Initial arch wires for alignment of crooked teeth with fixed orthodontic braces

Comparison: 2 0.014 inch superelastic NiTi wire versus 0.014 inch NiTi wire

Outcome: 5 Pain intensity (VAS (6th day))

Study or subgroup	0.014 superelastic NiTi N	Mean(SD)	0.014 NiTi N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Mean Difference IV,Fixed,95% CI
Fernandes 1998	60	8.8 (13.4)	65	9.3 (14.5)		-0.50 [-5.39, 4.39]



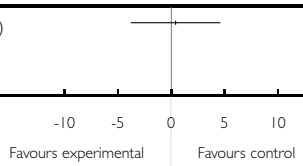
Analysis 2.6. Comparison 2 0.014 inch superelastic NiTi wire versus 0.014 inch NiTi wire, Outcome 6 Pain intensity (VAS (7th day)).

Review: Initial arch wires for alignment of crooked teeth with fixed orthodontic braces

Comparison: 2 0.014 inch superelastic NiTi wire versus 0.014 inch NiTi wire

Outcome: 6 Pain intensity (VAS (7th day))

Study or subgroup	0.014 superelastic NiTi N	Mean(SD)	0.014 NiTi N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Mean Difference IV,Fixed,95% CI
Fernandes 1998	65	7.1 (12.9)	59	6.7 (11)		0.40 [-3.81, 4.61]



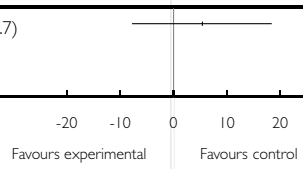
Analysis 3.1. Comparison 3 0.014 inch superelastic NiTi wire versus 0.015 inch multistrand stainless steel wire, Outcome 1 Pain intensity (VAS (1st day)).

Review: Initial arch wires for alignment of crooked teeth with fixed orthodontic braces

Comparison: 3 0.014 inch superelastic NiTi wire versus 0.015 inch multistrand stainless steel wire

Outcome: 1 Pain intensity (VAS (1st day))

Study or subgroup	0.014 superelastic NiTi N	Mean(SD)	0.015 multistand SS N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Mean Difference IV,Fixed,95% CI
Jones 1992	21	29 (22.4)	21	23.7 (20.7)		5.30 [-7.74, 18.34]



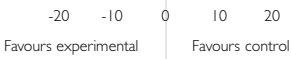
Analysis 3.2. Comparison 3 0.014 inch superelastic NiTi wire versus 0.015 inch multistrand stainless steel wire, Outcome 2 Pain intensity (VAS (2nd day)).

Review: Initial arch wires for alignment of crooked teeth with fixed orthodontic braces

Comparison: 3 0.014 inch superelastic NiTi wire versus 0.015 inch multistrand stainless steel wire

Outcome: 2 Pain intensity (VAS (2nd day))

Study or subgroup	0.014 superelastic NiTi N	Mean(SD)	0.015 multistand SS N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Mean Difference IV,Fixed,95% CI
Jones 1992	21	19.6 (21.2)	21	25 (24.4)		-5.40 [-19.22, 8.42]



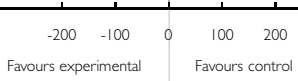
Analysis 3.3. Comparison 3 0.014 inch superelastic NiTi wire versus 0.015 inch multistrand stainless steel wire, Outcome 3 Pain intensity (VAS (3rd day)).

Review: Initial arch wires for alignment of crooked teeth with fixed orthodontic braces

Comparison: 3 0.014 inch superelastic NiTi wire versus 0.015 inch multistrand stainless steel wire

Outcome: 3 Pain intensity (VAS (3rd day))

Study or subgroup	0.014 superelastic NiTi N	Mean(SD)	0.015 multistand SS N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Mean Difference IV,Fixed,95% CI
Jones 1992	21	12.6 (11.4)	21	20.6 (21)		-8.00 [-18.22, 2.22]



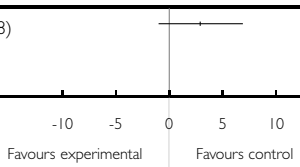
Analysis 3.4. Comparison 3 0.014 inch superelastic NiTi wire versus 0.015 inch multistrand stainless steel wire, Outcome 4 Pain intensity (VAS (4th day)).

Review: Initial arch wires for alignment of crooked teeth with fixed orthodontic braces

Comparison: 3 0.014 inch superelastic NiTi wire versus 0.015 inch multistrand stainless steel wire

Outcome: 4 Pain intensity (VAS (4th day))

Study or subgroup	0.014 superelastic NiTi N	Mean(SD)	0.015 multistand SS N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Mean Difference IV,Fixed,95% CI
Jones 1992	21	5.5 (7.9)	21	2.6 (4.8)		2.90 [-1.05, 6.85]



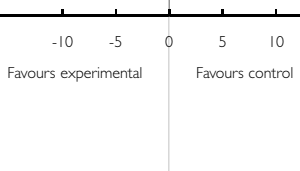
Analysis 3.5. Comparison 3 0.014 inch superelastic NiTi wire versus 0.015 inch multistrand stainless steel wire, Outcome 5 Pain intensity (VAS (5th day)).

Review: Initial arch wires for alignment of crooked teeth with fixed orthodontic braces

Comparison: 3 0.014 inch superelastic NiTi wire versus 0.015 inch multistrand stainless steel wire

Outcome: 5 Pain intensity (VAS (5th day))

Study or subgroup	0.014 superelastic NiTi N	Mean(SD)	0.015 multistand SS N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Mean Difference IV,Fixed,95% CI
Jones 1992	21	4.1 (6.1)	21	2.6 (4.8)		1.50 [-1.82, 4.82]



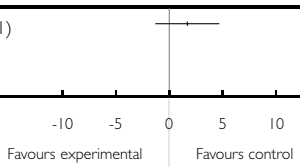
Analysis 3.6. Comparison 3 0.014 inch superelastic NiTi wire versus 0.015 inch multistrand stainless steel wire, Outcome 6 Pain intensity (VAS (6th day)).

Review: Initial arch wires for alignment of crooked teeth with fixed orthodontic braces

Comparison: 3 0.014 inch superelastic NiTi wire versus 0.015 inch multistrand stainless steel wire

Outcome: 6 Pain intensity (VAS (6th day))

Study or subgroup	0.014 superelastic NiTi N	Mean(SD)	0.015 multistand SS N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Mean Difference IV,Fixed,95% CI
Jones 1992	21	2.9 (6.2)	21	1.2 (3.1)		1.70 [-1.26, 4.66]



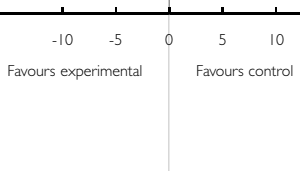
Analysis 3.7. Comparison 3 0.014 inch superelastic NiTi wire versus 0.015 inch multistrand stainless steel wire, Outcome 7 Pain intensity (VAS (7th day)).

Review: Initial arch wires for alignment of crooked teeth with fixed orthodontic braces

Comparison: 3 0.014 inch superelastic NiTi wire versus 0.015 inch multistrand stainless steel wire

Outcome: 7 Pain intensity (VAS (7th day))

Study or subgroup	0.014 superelastic NiTi N	Mean(SD)	0.015 multistand SS N	Mean(SD)	Mean Difference IV,Fixed,95% CI	Mean Difference IV,Fixed,95% CI
Jones 1992	21	1.2 (2.5)	21	0.5 (1.6)		0.70 [-0.57, 1.97]

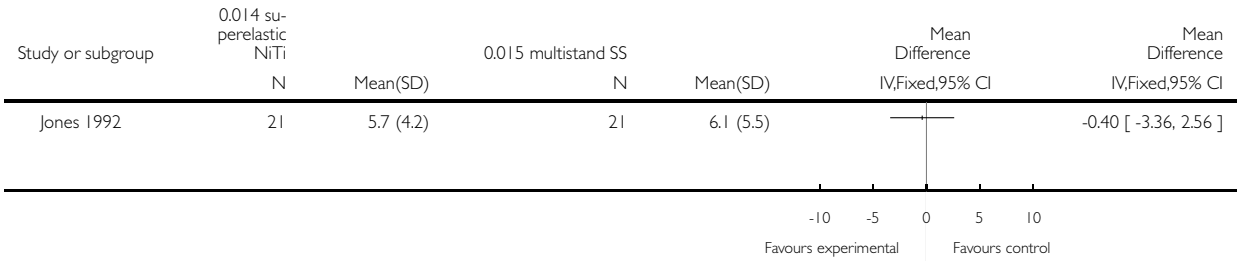


Analysis 3.8. Comparison 3 0.014 inch superelastic NiTi wire versus 0.015 inch multistrand stainless steel wire, Outcome 8 Pain intensity (VAS (over 14 days)).

Review: Initial arch wires for alignment of crooked teeth with fixed orthodontic braces

Comparison: 3 0.014 inch superelastic NiTi wire versus 0.015 inch multistrand stainless steel wire

Outcome: 8 Pain intensity (VAS (over 14 days))



ADDITIONAL TABLES

Table 1. Validity assessment of included trials

Trial	Sequence generation	Concealed allocation	Blind outcome assessment	Withdrawals	Overall risk of bias
Cobb 1998	Unclear	Unclear	Unclear	Clear description but no intention-to-treat analysis	High
Evans 1998	Unclear	Unclear	Unclear	Clear description but no intention-to-treat analysis	High
Fernandes 1998	Unclear	Unclear	Unclear	No drop outs	High
Jones 1992	Unclear	Unclear	Unclear	Clear description but no intention-to-treat analysis	High
O'Brien 1990	Yes	Yes	Yes	No drop outs	Low
Pandis 2009	Yes	Yes	Yes	No drop outs	Low
West 1995	Yes	Unclear	Unclear	No drop outs	Moderate

APPENDICES

Appendix 1. MEDLINE (OVID) search strategy

1. exp Orthodontic Wires/
2. "orthodontic wire$".mp.
3. archwire$ or "arch wire" or arch-wire$.mp.
4. "superelastic wire" or "super-elastic wire".mp.
5. "stainless steel wire"or "stainless-steel wire".mp.
6. (NiTi adj3 wire$) or (Ni-Ti adj3 wire$) or ("nickel titanium" adj3 wire) or (nickel-titanium adj3 wire).mp.
7. (CuNiTi adj3 wire$) or (Cu-NiTi adj3 wire$) or (Cu-Ni-Ti adj3 wire$) or (copper-nickel-titanium adj3 wire) or ("copper nickel titanium" adj3 wire).mp.
8. or/1-7

Appendix 2. Cochrane Oral Health Group's Trials Register search strategy

("orthodontic wire*" or archwire* or "arch wire*" or arch-wire* or "superelastic wire*" or "super-elastic wire*" or "stainless steel wire*" or "stainless-steel wire*" or NiTi or Ni-Ti or "nickel titanium wire*" or "nickel-titanium wire*")

Appendix 3. CENTRAL search strategy

#1 MeSH descriptor ORTHODONTIC WIRES explode all trees
#2 (archwire* in All Text or "arch wire*" in All Text or arch-wire* in All Text or "orthodontic wire*" in All Text)
#3 ("superelastic wire*" in All Text or "super-elastic wire*" in All Text)
#4 ("stainless steel wire*" in All Text or "stainless-steel wire*" in All Text)
#5 ((NiTi in All Text near/6 wire in All Text) or (Ni-Ti in All Text near/6 wire in All Text) or ("nickel titanium" in All Text near/6 wire in All Text) or (nickel-titanium in All Text near/6 wire in All Text))
#6 (#1 or #2 or #3 or #4 or #5)

Appendix 4. EMBASE via OVID search strategy

1. exp Orthodontic Wires/
2. "orthodontic wire$".mp.
3. archwire$ or "arch wire" or arch-wire$.mp.
4. "superelastic wire" or "super-elastic wire".mp.
5. "stainless steel wire" or "stainless-steel wire".mp.
6. (NiTi adj/3 wire$) or (Ni-Ti adj/3 wire$) or ("nickel titanium" adj/3 wire$) or (nickel-titanium adj/3 wire$).mp.
7. or/1-6

Appendix 5. Cochrane search filter for EMBASE via OVID

1. random$.ti,ab.
2. factorial$.ti,ab.
3. (crossover$ or cross over$ or cross-over$).ti,ab.
4. placebo$.ti,ab.
5. (doubl$ adj blind$).ti,ab.
6. (singl$ adj blind$).ti,ab.
7. assign$.ti,ab.
8. allocat$.ti,ab.
9. volunteer$.ti,ab.
10. CROSSOVER PROCEDURE.sh.

11. DOUBLE-BLIND PROCEDURE.sh.
12. RANDOMIZED CONTROLLED TRIAL.sh.
13. SINGLE BLIND PROCEDURE.sh.
14. or/1-13
15. ANIMAL/ or NONHUMAN/ or ANIMAL EXPERIMENT/
16. HUMAN/
17. 16 and 15
18. 15 not 17
19. 14 not 18

Appendix 6. Cochrane search filter for MEDLINE via OVID

1. randomized controlled trial.pt.
2. controlled clinical trial.pt.
3. randomized.ab.
4. placebo.ab.
5. drug therapy.fs.
6. randomly.ab.
7. trial.ab.
8. groups.ab.
9. or/1-8
10. animals.sh. not (humans.sh. and animals.sh.)
11. 9 not 10

HISTORY

Protocol first published: Issue 3, 2009

Review first published: Issue 4, 2010

CONTRIBUTIONS OF AUTHORS

- Yan Wang and Fan Jian were responsible for designing and co-ordinating the review, extracting data from papers and writing to authors of the papers for additional information. They contributed equally to this review.
- Wenli Lai, Zhihe Zhao and Zongdao Shi organised the retrieval of papers.
- Fan Jian and Grant McIntyre were responsible for screening search results, screening retrieved papers against inclusion criteria, data collection for the review, obtaining copies of trials, and extracting data from papers.
- Taixiang Wu and Declan T Millett were responsible for appraising the quality of papers.
- Zhi Yang and Zhengyu Liao were responsible for obtaining and screening data on unpublished studies and entering the data into RevMan.
- All review authors contributed to analysis and interpretation of the data, and to writing the review.

DECLARATIONS OF INTEREST

The participating review authors declare that they have no financial conflict of interest and that they do not have any associations with industry regarding the subject of this review.

INDEX TERMS

Medical Subject Headings (MeSH)

*Dental Alloys; Orthodontic Brackets [*standards]; Orthodontic Wires [adverse effects; *standards]; Randomized Controlled Trials as Topic; Root Resorption [etiology]; Tooth Movement [adverse effects; *instrumentation]; Toothache [etiology]

MeSH check words

Humans